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Relationships between safety climate and safety performance of building repair, maintenance, minor alteration, and addition (RMAA) works

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ABSTRACT

The importance of repair, maintenance, minor alteration, and addition (RMAA) works is increasing in many built societies. When the volume of RMAA works increases, the occurrence of RMAA accidents also increases. Safety of RMAA works deserves more attention; however, research in this important topic remains limited. Safety climate is considered a key factor that influences safety performance. The present study aims to determine the relationships between safety climate and safety performance of RMAA works, thereby offering recommendations on improving RMAA safety. Questionnaires were dispatched to private property management companies, maintenance sections of quasi-government developers and their subcontractors, RMAA sections of general contractors, small RMAA contractors, building services contractors and trade unions in Hong Kong. In total, data from 396 questionnaires were collected from RMAA workers. The sample was divided into two equal-sized sub-samples. On the first sub-sample SEM was used to test the model, which was validated on the second sub-sample. The model revealed a significant negative relationship between RMAA safety climate and incidence of self-reported near misses and injuries, and significant positive relationships between RMAA safety climate and safety participation and safety compliance respectively. Higher RMAA safety climate was positively associated with a lower incidence of self-reported near misses and injuries and higher levels of safety participation and safety compliance.

Keywords: Safety climate; safety performance; repair and maintenance

1. Introduction

Repair, maintenance, minor alteration, and addition (RMAA) works have been largely overlooked during the construction market boom. In fact, the volume of RMAA works often accounts for a considerable size of the total construction volume in many developed societies. For example, the RMAA sector accounted for an average of 50.2% of the construction volume in Hong Kong from 2006 to 2010 (Census and Statistics Department, 2007, 2008, 2009, 2010, 2011). The RMAA sector is expected to expand further due to the rising concerns for the safety of aging buildings and sustainability in the built environment. Repair and maintenance of dilapidated buildings is needed to protect the safety of the occupants and the public; whereas remodeling and retrofitting is needed to preserve or upgrade the building value (Yiu, 2007). With the rising importance of the RMAA sector, safety problems of this sector deserve more attention (Hon et al.,

2010). The RMAA sector accounted for six out of ten (66.7%) fatal cases in the construction industry of Hong Kong in 2010. The RMAA sector accounted for 44.7% of accidents in the construction industry in 2011 while it only accounted for 39.2% of the construction volume in the same period (Legislative Council, 2011a, 2011b). Research into safety of the RMAA sector; however, remains scarce.

Unsafe behavior is a decisive factor for accident to occur (Reason, 1995). Unsafe behavior often occurs because safety measures are likely to entail modest benefits but immediate costs, such as slower pace, extra effort or personal discomfort. If the likelihood of injury is underestimated in a seemingly safe environment, the expected utility of the unsafe behavior exceeds that of the safe behavior. Unsafe behavior is also naturally reinforced because people tend to place higher value on short-term results. In this sense, deterring unsafe behavior is a significant managerial challenge (Zohar, 2002).

Since RMAA works mainly involve labor rather than machines, most of the accidents occurred because of unsafe behavior rather than machine failure. However, unsafe behavior is only an ostensible cause or symptom, and other more fundamental factors also need to be considered. For example, building design affects safety of construction workers. As suggested by Behm (2005), safety hazards are often “designed into” the construction projects. A holistic approach of accident causation should be adopted (Reason, 1997). Broader organizational and contextual factors leading to unsafe behavior should not be neglected. A behavioral approach, which considers how employees think, behave, respond to situations, and how the work environment impacts upon personnel attitudes and behavior, would likely be more effective in managing safety of RMAA works (Lingard and Rowlinson, 2005).

Safety climate has been a useful construct to improve safety in the past few decades (Zohar, 2010). A handful of research studies show that a positive relationship between safety climate and safety performance exists in construction. For example, Mohamed (2002), Chan et al. (2005), and Choudhry et al. (2009) have successfully established a positive relationship between safety climate and safety performance on construction projects; however, little research has been done in the RMAA sector, which is increasingly important not only in Hong Kong, but also in other developed societies.

Safety practices of RMAA works differ from those in new construction works. Most RMAA contracting companies are small/medium-sized specialty contractors of RMAA works. The small/medium-sized companies often have limited resources for safety (Lamm, 1997). Unlike greenfield projects, RMAA job sites are often found in occupied buildings (Chan et al., 2010). RMAA workers may underestimate the risks of working in an occupied environment which does not resemble a construction site. Small size and widely scattered locations of RMAA projects make safety supervision more difficult, inefficient, and costly than those of new works. Close safety supervision on a RMAA contract with small contract sum and short duration of work is not cost effective (Hon et al., 2012). In light of these subtle differences, previous safety climate research findings on new construction projects may not be fully relevant to RMAA works. The relationships between safety climate and safety performance of the RMAA sector require further investigation.

This paper reports part of the findings of a wider scope safety research project on RMAA works in Hong Kong. It aims to determine the relationships between safety climate and safety performance of RMAA projects. The current study fills the knowledge

gap of limited safety climate research in the RMAA sector of construction. A model unveiling the relationship of safety climate and safety performance of RMAA works would be useful for safety professionals in the industry to measure, monitor, and improve the safety performance of RMAA works.

2. Safety climate

Zohar (1980) applied the concept of behavioural climate for safety and produced a seminal paper on safety climate in the early 80s. Since then, safety climate has been widely applied in different contexts. Zohar (1980, p. 96) defines safety climate as “a summary of molar perceptions that employees share about their work environments... a frame of reference for guiding appropriate and adaptive task behaviors”. As stated by Zohar (2003), safety climate reflects the true perceived priority of safety in an organization. Some researchers defined safety climate as a current-state reflection of the underlying safety culture (e.g., Mearns et al., 2001, 2003).

There is little consensus on the number and content of safety climate factors. Flin et al. (2000) identified five most frequently-occurring factors from 18 safety climate scales of different industries, they were: management/supervision, the safety system, risk, work pressure and competence. As reviewed by Hon et al. (2013), management commitment to safety, safety rules and procedures, and workers’ involvement in safety, were the three most common safety climate factors found in construction (Dedobbeleer & Béland, 1991; Mohamed, 2002; Fang et al., 2006; Choudhry et al., 2009; Zhou et al., 2011). Safety climate studies in the construction industry have been focusing on new construction projects (e.g. Chan et al. 2005; HSE, 2012) but our understanding of the safety climate of RMAA works is largely unrealised.

3. Safety performance

Earlier safety studies tended to use statistical data of accidents or injuries to measure safety performance. By contrast, apart from actual injury records, more recent studies have also used alternative data such as self-reported injury data collected through questionnaires (e.g. Siu et al., 2004; Huang et al., 2006) and self-reporting has been shown to be a reliable and valid source of injury data (Begg et al., 1999; Gabbe et al., 2003). According to Gabbe et al. (2003), the accuracy of self-reported injuries could be as high as 80%. However, accidents or injuries are reactive measures and are relatively infrequent. They may not be effective indicators of safety because they only reflect occurrences of failures (Cooper and Phillips, 2004). They are also “insufficiently sensitive, of dubious accuracy, retrospective, and ignore risk exposure” (Glendon and Litherland, 2001, p. 161). Lingard et al. (2011) have also reported that injuries resulting in lost time and medical treatment occur infrequently and are ineffective indicators of safety performance. They suggested using a more fine-grained measure of workgroup safety performance, such as micro-accidents or minor (non-reportable) injuries in future research. According to Beus et al. (2010, p. 717) “safety climate should be more effective in predicting injuries of a less serious nature”. It is because minor injuries, which often come before serious ones, are more proximal to safety climate than serious injuries.

In light of the deficiency in using injury as a proxy of safety performance, a growing number of studies have attempted to use safety behavior as a measure of safety performance. Safety performance can be defined as evaluative “actions or behaviors that individuals exhibit in almost all jobs to promote the health and safety of workers, clients, the public, and the environment” (Burke et al., 2002, p. 432). According to Neal and Griffin (2004), safety performance can be measured with *safety compliance* and *safety participation*.

Safety compliance is defined by Griffin and Neal (2000) as following rules in core safety activities. This includes “obeying safety regulations, following correct procedures, and using appropriate equipment” (Neal and Griffin, 2004, p. 16). It refers to “the core activities that individuals need to carry out to maintain workplace safety. These procedures include adhering to standard work procedures and wearing personal protective equipment” (Neal and Griffin, 2006, p. 947). Safety participation refers to “behaviors that do not directly contribute to an individual’s personal safety but that do help to develop an environment that supports safety” (Neal and Griffin, 2006, p. 947).

4. Relationships between safety climate and safety performance

4.1 Theoretical linkages

Social exchange theory and expectancy-valence theory are two theoretical mechanisms that may help to explain and predict the relationship between safety climate and safety behavior (Neal and Griffin, 2006). Social exchange theory postulates that, when an organization cares for the well-being of employees (i.e., the organization has a positive safety climate), the employees are likely to develop implicit obligations to perform duties, using behavior beneficial to the organization. Apart from their standard core work duties, they also perform *organizational citizenship behavior*, i.e., extra-role functions other than core work activities. Hofmann and Morgeson (1999) have found that when an organization emphasizes safety, its employees reciprocate by complying with established safety procedures (Neal and Griffin, 2006).

The expectancy-valence theory postulates that motivation is a combination of employees’ valence, expectancy and instrumentality. Valence is the depth of want that an employee has for extrinsic (e.g. promotion) or intrinsic (e.g. satisfaction) rewards. Expectancy refers to level of confidence an employee is capable of achieving the goal. Instrumentality is an employee’s perception of being rewarded as promised by the management (Vroom, 1964). In terms of safety performance, employees will behave safely when they perceive that such behavior will bring valued intrinsic or extrinsic outcomes. When an organization truly values safety, there is a high level of safety climate in the organization. Based on behavior-outcome expectancies, employees are likely to behave safely because they expect that their safety behavior would be rewarded and such behavior would bring a valuable outcome to them (Neal and Griffin, 2006).

4.2. Empirical relationships

The influence of safety climate on safety performance varies across different work settings and environments. Some studies found significant relationship between safety

climate and safety performance (Gillen et al., 2002; Siu et al., 2004; Pousette et al., 2008) whereas some did not (Glendon and Litherland, 2001; Cooper and Philips, 2004). Comprehensive meta-analysis studies of Clarke (2006) and Christian et al. (2009) on safety climate and safety performance indicated that safety climate is a significant factor affecting safety performance. Clarke's study (2006) revealed that safety climate and safety performance is consistently positively-related in prospective studies. A more recent meta-analysis study of Christian et al. (2009) also established significant relationships between safety climate and safety participation and safety compliance respectively. Safety climate helps to raise safety motivation and safety knowledge, leading to safer behavior and fewer accidents and injuries.

5. Research hypotheses

Based on the literature, a research model showing three research hypotheses for empirical testing is shown in Fig. 1.

(Insert Fig. 1 here)

The safety climate generally shows the importance of safety perceived by the employees in an organization. The level of safety climate affects the safety behavior and safety attitudes of employees in an organization. When safety perceptions are more favorable, employees are less likely to engage in unsafe acts, resulting in a lower chance of injury (Clarke, 2006). The first hypothesis, Hypothesis 1 (H1), can thus be generated as: *RMAA safety climate is negatively related to self-reported near misses and injuries.*

Safety participation is more on voluntary basis, and, perhaps outside of one's formal role. When managers and supervisors demonstrate their commitment to safety, their subordinates are more likely to reciprocate by participating in safety activities. The more positive the safety climate, the higher the level of the safety participation (Clarke, 2006), as hypothesized in Hypothesis 2 (H2): *RMAA safety climate is positively related to safety participation.*

A higher level of safety climate may imply better safety management, safety knowledge and awareness of safety within the company. In such a case, people are more likely to comply with safety rules and regulations (Clarke, 2006). Thus, Hypothesis 3 (H3) can be generated as: *RMAA safety climate is positively related to safety compliance.*

6. Research methods

6.1 Questionnaire design

A questionnaire was designed to explore the relationship between safety climate and safety performance of RMAA works. The questionnaire consisted of three parts. Part A asked 13 questions on personal attributes. Part B adopted 38 questions of the Safety Climate Index (SCI) survey developed by the Occupational Safety and Health Council (OSHC) of Hong Kong to measure safety climate of RMAA works. SCI was selected because it was written in both English and Chinese and was designed in the context of the construction industry of Hong Kong. Its validity and reliability had been verified by prior

research of the OSHC. Part C consisted of three broad indicators to measure safety performance: injuries, safety participation, and safety compliance.

6.1.1 RMAA safety climate

A second-order safety climate model for RMAA works which consisted of three factors encapsulating 22 questions (Appendix A) of the Safety Climate Index (SCI) survey of the Occupational Safety and Health Council (OSHC) of Hong Kong (OSHC, 2008) was employed. Detailed development of the second-order RMAA safety climate model has been reported in Hon et al. (2013). Three RMAA safety climate factors were: (F1) *Management commitment to OHS and employee involvement*; (F2) *Applicability of safety rules and work practices*; and (F3) *Responsibility for health and safety*. These questions were evaluated by the respondents in a five-point Likert scale, with “1” being “strongly disagree” and “5” being “strongly agree”. Measurement of safety climate is assumed at the individual level rather than at group level. According to James (1982, p. 219), the appropriate unit of theory for climate is individual because “climate involves a set of macro perceptions that reflect how environments are cognitively represented in terms of their psychological meaning and significance to the individual”. Cronbach’s Alpha of the RMAA safety climate was .89. Cronbach’s Alpha values of safety climate factors F1 to F3 were .88, .79 and .67 respectively.

6.1.2 Self-reported near misses and injuries

Four questions were utilized to capture near misses and occupational injuries of the respondents in the last 12 months with a 5-point ordinal scale (0 = Never; 1 = 1 time; 2 = 2-3 times; 3 = 4-5 times; 4 = Over 5 times). The questions were: “How many times have you exposed to a near miss incident of any kind at work?”; “How many times have you suffered from injury of any kind at work, but did not require absence from work?”; “How many times have you suffered from injury, which require absence from work not exceeding 3 consecutive days?” and “How many times have you suffered from injuries, which require absence from work exceeding 3 consecutive days?”. The questions were set in an ascending degree of injury severity with reference to the existing injury reporting requirement to the Labour Department. Since none respondents experienced injuries which require absence from work exceeding 3 consecutive days, this variable was excluded from the data analysis. Cronbach’s Alpha of the near misses and injuries was .80.

6.1.3 Safety participation

Two statements from Neal and Griffin (2006, p. 953) were modified to measure safety participation of the respondents with a 5-point ordinal scale (Appendix B). Having considered that small RMAA projects may not have formal safety programs, one of the statements listed in Neal and Griffin (2006, p. 953), “I promote the safety program within the organization”, was not selected. With examples given to enhance clarity, the two selected statements were posed as questions regarding the frequency of putting extra effort to improve safety of the workplace, and the frequency of voluntarily carrying out tasks or activities to improve workplace safety. Cronbach’s Alpha of the safety participation was .73.

6.1.4 Safety compliance

Two questions adopted from Mohamed (2002) were utilized to measure in terms of time (0% to 100%) the degree of safety compliance to all safety procedures by the respondents and their co-workers respectively (Appendix B). The first question was regarding the percentage of time the respondents follow all of the safety procedures for the jobs or tasks that the respondents perform, whereas the second question was regarding the percentage of time their coworkers follow all of the safety procedures for the jobs or tasks that they perform. Cronbach's Alpha of the safety compliance was .88.

6.2 Participants and procedures

The survey was administered between April and August in 2009. A pilot questionnaire was reviewed by 13 advisory group members in a focus group meeting. These advisory group members provided advice and industrial support for the research team. They were well experienced, including senior management of clients, RMAA contracting companies, property management companies, and government officials concerning occupational health and safety (OHS). First, a sampling framework consisting of clients, property management companies, RMAA contractors and subcontractors was designed. Then questionnaires were dispatched through industrial links of the advisory group members. With their facilitation, several private property management companies, maintenance sections of quasi-government developers and their subcontractors, RMAA sections of general contractors, small RMAA contractors, building services contractors and trade unions in Hong Kong participated in this study. In total, 844 questionnaires were sent out and 814 of them were duly returned from managers, supervisors and workers. The response rate was 96.3%. In order to establish the relationships between safety climate and safety performance of workers in the RMAA sector, a total of 396 completed questionnaires of frontline workers were selected for analysis in this paper.

6.3 Data analysis

Quantitative survey data were analyzed with statistical packages SPSS 18.0 (SPSS Inc., Chicago, IL, USA) for descriptive statistical analysis and LISREL 8.80 (Jöreskog and Sörbom, 2006) for structural equation modeling (SEM).

SEM technique was employed to test the relationship between safety climate and safety performance of RMAA works. SEM was selected because it can examine a series of separate, but interdependent, multiple regression equations simultaneously by specifying the structural model. It can take into account of latent variables and provide explicit estimates of error variance parameters (Byrne, 2009).

As for this study, safety climate is a latent variable that cannot be directly observed and measured. With SEM, a hypothetical model with multiple latent variables of safety climate and safety performance was constructed and tested against empirical data. Interdependencies of observed variables and latent variables were estimated simultaneously. As measurement errors were also considered, parameter estimates were more accurate.

Normality checking showed that the data of this study were not normally distributed. As the dataset of this study is reasonably large, Satorra-Bentler scaled chi-square (χ^2) was

chosen for assessing goodness-of-fit of the SEM model. It is an adjusted χ^2 statistic which attempts to correct for the bias introduced when data are markedly non-normal in distribution (Satorra and Bentler, 2001). A non-significant, small χ^2 value indicates that the observed data are not significantly different from the hypothesized model. However, as formula of computing χ^2 is related to sample size, nearly all models are evaluated as incorrect as sample size increases. For this reason, the ratio of χ^2 to the degrees of freedom (χ^2/df) has been commonly used as an alternative fit index. If χ^2/df is less than 2, the model is a good fit (Ullman, 2006). In addition to χ^2/df , root mean square error of approximation (RMSEA), Comparative Fit Index (CFI) and Non-normed Fit Index (NNFI) were chosen to assess goodness-of-fit of the SEM model. As a rule, RMSEA value of less than .05 (lower value of 90% confidence interval (CI) of RMSEA no greater than .05 and upper value less than .08), CFI and NNFI of .95 or greater indicate good fit (Diamantopoulos and Siguaw, 2000).

To test for model stability, cross-validation was done by a split-sample approach (Diamantopoulos and Siguaw, 2000). Data were randomly split into a calibration sub-sample and a validation sub-sample. Tight cross-validation, which is the most rigorous way to examine the extent to which a model replicates in samples other than the one which it was derived, was conducted by fixing all the parameters across the calibration sub-sample and the validation sub-sample (Diamantopoulos and Siguaw, 2000).

7. Results

Descriptive statistics and the correlations of the included variables are shown in Table 1. As shown in Table 2, the goodness-of-fit statistics indicated that the hypothesized model fits the calibration sub-sample and the validation sub-sample well. The model has good model stability. Results of tight cross-validation, that is, fixing all the parameters across the calibration and validation sub-samples, show reasonable fit. Full structural equation models of the calibration and validation sub-samples can be found in Appendices C and D.

(Insert Table 1, Table 2 & Fig. 2 here)

Hypothesis (H1) is supported. The relationship between RMAA safety climate and self-reported near misses and injuries was significantly negative. As shown in Fig. 2, the standardized path coefficient from RMAA safety climate to injuries was -.35 in the calibration sub-sample and -.21 in the validation sub-sample. That means, one unit of increase in the RMAA safety climate led to an approximately .2 to .4 unit of decrease in the number of self-reported near misses and injuries. *Hypothesis (H2) is supported.* The relationship between RMAA safety climate and safety participation is significantly positive. Referring to Fig. 2, the standardized path coefficient from RMAA safety climate to safety participation was .28 in the calibration sub-sample and .18 in the validation sub-sample. That means, one unit of increase in the RMAA safety climate led to an approximately .2 to .3 unit of increase in safety participation. *Hypothesis (H3) is supported.* The relationship between RMAA safety climate and safety compliance is significantly positive. With reference to Fig. 2, the standardized path coefficient from RMAA safety climate to safety compliance was .65 in the calibration sub-sample and .62

in the validation sub-sample. That means, one unit of increase in the RMAA safety climate will lead to an approximately .6 to .7 unit of increase in safety compliance. When estimating the relationships between RMAA safety climate and safety performance, safety compliance has the highest standardized path coefficient (.65 in the calibration sub-sample; .62 in the validation sub-sample) when compared with near misses and injuries, and safety participation. The relationship between RMAA safety climate and safety participation was the weakest, and was in fact even weaker than near misses and injuries.

It is acknowledged that the statistical relationship between safety climate and safety performance may be biased due to common method variance problem of single source data collection. Harman's one factor test, a statistical post-hoc remedy to control for common method variance, was conducted. If there is substantial amount of common method variance, only a single factor or a general factor accounting for a large portion of variance will emerge from the factor analysis (Podsakoff and Organ, 1986). The factor analysis of the dependent and independent variables resulted in seven factors with the first factor accounting for 28.74% out of 62.78% of the total variance explained. Although the Harman's one factor test has limitations (Podsakoff and Organ, 1986), the result indicates that common method variance due to single source biases is not substantial in this study. The result is in line with Christian et al. (2009) that common methods bias is not a major concern in the safety domain.

8. Discussion and concluding remarks

Echoing with the meta-analysis of Beus et al. (2010), this study shows that the relationship between safety climate and safety performance is generally established in the context of RMAA works. Safety climate of RMAA works was positively related to safety participation and safety compliance but negatively related to self-reported near misses and injuries. However, as Beus et al. (2010) suggested, there are potential moderators to the relationship between safety climate and safety performance. In view of the variations of the empirical relationships between safety climate and safety performance in different industry contexts, industry context may be such a potential moderator; however, further investigation would be required to draw a more solid conclusion.

Christian et al. (2009) found that safety climate was inclined to have a stronger relationship with safety participation than with safety compliance. They suggested that complying with safety rules and regulation was the obligation of workers, so that safety climate had little influence on such compulsory behavior. In stark contrast with Christian et al. (2009), the findings of this study show that the safety climate of RMAA works only exert a small influence on the level of safety participation, but a much stronger influence on the level of safety compliance. This indicates that safety participation may be predominantly affected by variables other than the RMAA safety climate. One possible variable could be personal attitude towards safety. Besides, typical characteristics of RMAA works, such as short duration and minute tasks, also restrain RMAA workers from safety participation.

Unlike safety compliance, which is considered the obligation of the employee, safety participation involves extra-role activities that are voluntary. More self-motivation is needed to perform safety participation than safety compliance. Workers are, by

definition, obliged to comply with safety rules and regulation; however, it is not always the case in the context of RMAA works. Very often, RMAA workers tend to rely on their experience rather than complying with safety rules and regulations, due to low safety awareness of RMAA workers (Hon et al., 2012). The prevailing safety climate level of RMAA works successfully motivates RMAA workers to comply with safety rules and regulations; however, the motivation is not sufficiently strong to encourage them to participate in extra safety activities.

As in the construction industry, Choudhry et al. (2009) found that the safety climate factor *management commitment and employee involvement* had a stronger relationship with perceived safety performance than the other safety climate factor *inappropriate safety procedures and work practices*. The current study on RMAA works; however, has found that (F2) *applicability of safety rules and practices* has a stronger relationship with safety compliance, reflecting the peculiar situation of the RMAA sector. Appropriate safety rules and clear practices for RMAA works are currently lacking. RMAA works practitioners perceive that appropriate safety rules and clear practices for RMAA works will enhance their safety performance.

Although the construction industry generally has clear existing safety rules and best practice guidelines, the RMAA sector urgently needs a set of safety rules and practice guidelines that can better meet the specific needs of the RMAA works to follow. Despite the presence of some practice guidelines for implementation of property management companies, such efforts are yet to be comprehensive. Moreover, many small/medium-sized RMAA contracting companies may not even be aware that these practice guidelines exist. Referring to Legislative Council (2011c), small RMAA contractors are generally less attentive to occupational safety and health legislation. Proper RMAA safety rules and safety practices should be laid down and promoted in the RMAA sector.

Safety climate factors, if managed properly, can result in better safety performance of RMAA works. Deficiencies in management procedures and safety system can be detected in the measurement of safety climate (Choudhry et al., 2009). *Management commitment to OHS* was perceived by the RMAA workers as an important factor of safety climate. It stems from genuine concern for the well-being of the employee. Such management commitment only occurs when top management truly believes that good safety performance is not a random occurrence but a calculated result of specific management actions (Hinze, 2006). Transparent and good communication with workers and supervisors is necessary. Safety should be integrated with other company goals. To enlist *employee involvement*, the RMAA workers need to have a clear understanding of their OHS responsibilities and the health and safety risks they will face and they should be assessed and praised for working safely.

The factor *applicability of safety rules and work practices* contributes significantly to safety performance. It is important that safety rules and work practices should be up-to-date, technically correct, and clear (Choudhry et al., 2009), and should help the RMAA workers avoid potential risks and hazards, and conduct tasks safely. They also need to be upheld and properly enforced. To have a positive perception of *responsibility for health and safety*, RMAA workers must have a correct assessment to risk and a locus of control for accidents (Hinze, 2006). In addition, the contracting companies also need to properly bear the responsibility for health and safety. Accident investigation should identify the

root causes of accidents, not who should be blamed. Proactive safety measures should be performed on a daily basis, not be delayed until someone is injured.

This study exerts profound impact on construction safety of developed societies. It is expected that the RMAA sector will play an increasingly important role in the construction market of developed societies because there are fewer buildings to be built but more to be repaired and maintained. In general, safety of new construction sites in developed societies has been improved; this is not the case for RMAA works. Although this study was conducted in Hong Kong, findings can be extrapolated to other developed cities which have expanding RMAA sectors and increasing accidents of RMAA works.

To conclude, with the help of SEM, the intricate relationships of safety climate of RMAA works, and its safety climate factors and multifaceted safety performance have been simultaneously estimated. To the author's knowledge, this is the first study of its kind in the RMAA sector of the construction industry to successfully test the theoretical model of safety climate and safety performance using SEM techniques.

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(Insert Appendices A to D there)

References

- Begg, D.J., Langley, J.D., Williams, S.M., 1999. Validity of self-reported crashes and injuries in a longitudinal study of young adults. *Injury Prevent* 5, 142-144.
- Behm, M., 2005. Linking construction fatalities to the design for construction safety concept. *Safety Science* 43, 589-611.
- Beus, J.M., Payne, S.C., Bergman, M.E., Arthur, W. Jr., 2010. Safety climate and injuries: An examination of theoretical and empirical relationships. *Journal of Applied Psychology* 95 (4), 713-727.
- Burke, M.J., Sarpy, S.A., Tesluk, P.E., Smith-Crowe, K., 2002. General safety performance: a test of a grounded theoretical model. *Personnel Psychology* 55, 429-457.
- Byrne, B.M., 2009. *Structural Equation Modeling with AMOS: Basic Concepts, Applications and Programming*, 2nd ed., Taylor and Francis Group, Routledge.
- Census and Statistics Department, 2007. Report on the Quarterly Survey of Construction Output (4th Quarter 2006), C&SD, The HKSAR Government. Retrieved June 21, 2011

- from http://www.censtatd.gov.hk/products_and_services/products/publications/statistical_report/commerce_and_industry/index_cd_B1090002_dt_back.jsp
- Census and Statistics Department, 2008. Report on the Quarterly Survey of Construction Output (4th Quarter 2007), C&SD, The HKSAR Government. Retrieved June 21, 2011
- from http://www.censtatd.gov.hk/products_and_services/products/publications/statistical_report/commerce_and_industry/index_cd_B1090002_dt_back.jsp
- Census and Statistics Department, 2009. Report on the Quarterly Survey of Construction Output (4th Quarter 2008), C&SD, The HKSAR Government. Retrieved June 21, 2011
- from http://www.censtatd.gov.hk/products_and_services/products/publications/statistical_report/commerce_and_industry/index_cd_B1090002_dt_back.jsp
- Census and Statistics Department, 2010. Report on the Quarterly Survey of Construction Output (4th Quarter 2009), C&SD, The HKSAR Government. Retrieved June 21, 2011
- from http://www.censtatd.gov.hk/products_and_services/products/publications/statistical_report/commerce_and_industry/index_cd_B1090002_dt_back.jsp
- Census and Statistics Department, 2011. Report on the Quarterly Survey of Construction Output (4th Quarter 2010), C&SD, The HKSAR Government. Retrieved June 21, 2011
- from http://www.censtatd.gov.hk/products_and_services/products/publications/statistical_report/commerce_and_industry/index_cd_B1090002_dt_back.jsp
- Chan, A.P.C., Wong, F.K.W., Yam, M.C.H., Chan, D.W.M., Hon, C. K. H., Wang, Y, Dingsdag, D., & Biggs, H., 2010. RMAA safety performance – how does it compare with Greenfield projects? In: Proceedings of the CIB World Congress 2010, Building a Better World, The Lowry, Salford Quays, United Kingdom, 10-13 May 2010, Paper ID:457, p.154.
- Chan, A.P.C., Wong, F.K.W., Yam, M.C.H., Chan, D.W.M., Ng, J.W.S., Tam, C.M., 2005. From Attitude to Culture - Effect of Safety Climate on Construction Safety. Research Monograph, Construction Safety Research Group, Research Centre for Construction and Real Estate Economics, Department of Building and Real Estate, The Hong Kong Polytechnic University.
- Choudhry, R.M., Fang, D., Lingard, H., 2009. Measuring safety climate of a construction company. *Journal of Construction Engineering and Management* 135 (9), 890-899.
- Christian, M.S., Bradley, J.C., Wallace, J.C., Burke, M.J. 2009. Workplace safety: A meta-analysis of the roles of person and situation factors. *Journal of Applied Psychology* 94 (5), 1103-1127.
- Clarke, S., 2006. The relationship between safety climate and safety performance: A meta-analytic review. *Journal of Occupational Health Psychology* 11(4), 315-327.
- Cooper, M.D., Phillips, R.A., 2004. Exploratory analysis of the safety climate and safety behavior relationship. *Journal of Safety Research* 35 (5), 497-512.
- Dedobbeleer, N. and Béland, F., 1991. A safety climate measure for construction sites. *Journal of Safety Research* 22 (2), 97-103.
- Diamantopoulos, A., Siguaw, J.A., 2000. *Introducing LISREL: A Guide for the Uninitiated*. Sage Publications Ltd., Thousand Oaks, California.

- Fang, D., Chen, Y., Wong, L., 2006. Safety climate in construction industry: A case study in Hong Kong. *Journal of Construction Engineering and Management* 132 (6), 573-584.
- Flin, R., Mearns, K., O'Connor, P., Bryden, R., 2000. Measuring safety climate: Identifying the common features. *Safety Science* 34 (1-3), 177-192.
- Gabbe, B.J., Finch, C.F. Bennel, K.L., Wajswelner, H., 2003. How valid is a self reported 12 month sports injury history? *British Journal of Sports Medicine* 37 (6), 545-547.
- Gillen, M., Baltz, D., Gassel, M., Kirsch, L., Vaccaro, D., 2002. Perceived safety climate, job demands, and coworker support among union and non-union injured construction workers. *Journal of Safety Research* 33, 33-51.
- Glendon, A.I., Litherland, D.K., 2001. Safety climate factors, group differences and safety behavior in road construction. *Safety Science* 39 (3), 157-188.
- Griffin, M. A., Neal, A. 2000. Perceptions of safety at work: A framework for linking safety climate to safety performance, knowledge, and motivation. *Journal of Occupational Health Psychology* 5 (3), 347-358.
- Health and Safety Executive (HSE), 2012. Safety culture on the Olympic Park. Research report RR942. Retrieved November 2, 2013 from <http://www.hse.gov.uk/research/rrpdf/rr942.pdf>
- Hinze, J. (2006). *Construction Safety*. 2nd ed., Alta Systems, Inc., Gainesville, Florida.
- Hofmann, D.A., Morgeson, F.P., 1999. Safety-related behavior as a social exchange: The role of perceived organizational support and leader-member exchange. *Journal of Applied Psychology* 84 (2), 286-296.
- Hon, C.K.H., Chan, A.P.C., Wong, F.K.W., 2010. An empirical study on causes of accidents of repair, maintenance, minor alteration and addition works in Hong Kong. *Safety Science* 48 (7), 894-901.
- Hon, C.K.H., Chan, A.P.C., Yam, M.C.H., 2012. Empirical study to investigate the difficulties of implementing safety practices in the repair and maintenance sector of Hong Kong. *Journal of Construction Engineering and Management* 138 (7), 877-884.
- Hon, C.K.H., Chan, A.P.C., Yam, M.C.H., 2013. Determining safety climate factors in the repair, maintenance, minor alteration, and addition sector of Hong Kong. *Journal of Construction Engineering and Management* 139 (5), 519-528.
- Huang, Y.H., Ho, M., Smith, G.S., Chen, P.Y., 2006. Safety climate and self-reported injury: assessing the mediating role of employee safety control. *Accident Analysis and Prevention* 38 (3), 425-43.
- James, L.R., 1982. Aggregation bias in estimates of perceptual agreement. *Journal of Applied Psychology* 67 (2), 219-229.
- Jöreskog, K.G., Sörbom, D., 2006. LISREL 8.80 for Windows [Computer Software]. Lincolnwood, IL: Scientific Software International, Inc.
- Lamm, F., 1997. Small businesses and OH&S advisors. *Safety Science* 25 (1-3), 153-161.
- Legislative Council, 2011a. Legislative Council Panel on Manpower - Hong Kong's Occupational Safety Performance in 2008 [LC Paper No. CB(2)2176/08-09(01)]. Retrieved July 7, 2011 from <http://www.legco.gov.hk/yr08-09/english/panels/mp/papers/mp0716cb2-2176-1-e.pdf>
- Legislative Council, 2011b. Legislative Council Panel on Manpower- Hong Kong's Occupational Safety Performance in 2010 [LC Paper No. CB(2)2044/10-11(11)].

Retrieved July 7, 2011 from <http://www.legco.gov.hk/yr10-11/english/panels/mp/papers/mp0617cb2-2044-11-e.pdf>

Legislative Council, 2011c. Occupational Safety Performance in Hong Kong.

Background brief prepared by the Legislative Council Secretariat for the meeting of Panel on Manpower on 17 June 2011. Retrieved May 8, 2013

from <http://www.legco.gov.hk/yr10-11/english/panels/mp/papers/mp0617cb2-2044-12-e.pdf>.

Lingard, H., Cooke, T., Blismas, N., 2011. Coworkers' response to occupational health and safety- an overlooked dimension of group-level safety climate in the construction industry? *Engineering, Construction and Architectural Management* 18 (2), 159-175.

Lingard, H., Rowlinson, S., 2005. *Occupational Health and Safety in Construction Project Management*. Spon Press, London and New York.

Mearns, K., Whitaker, S.M., Flin, R., 2001. Benchmarking safety climate in hazardous environments: a longitudinal, interorganizational approach. *Risk Analysis* 21 (4), 771-786.

Mearns, K., Whitaker, S.M., Flin, R., 2003. Safety climate, safety management practice and safety performance in offshore environments. *Safety Science* 41 (8), 641-680.

Mohamed, S., 2002. Safety climate in construction site environments. *Journal of Construction Engineering and Management* 128 (5), 375-384.

Neal, A., & Griffin, M. A., 2004. Safety climate and safety at work. In: Barling, J., Frone, M.R. (Eds.), *The Psychology of Workplace Safety*. American Psychological Association, Washington, D.C., pp. 15-34.

Neal, A., Griffin, M.A., 2006. A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. *Journal of Applied Psychology* 91 (4), 946-953.

Occupational Safety and Health Council (OSHC), 2008. *Construction Industry Safety Climate Index Software*. OSHC, Hong Kong.

Podsakoff, P.M., Organ, D.W., 1986. Self-reports in organizational research: Problems and prospects. *Journal of Management* 12 (4), 531-544.

Pousette, A., Larsson, S., Törner, M., 2008. Safety climate cross-validation, strength and prediction of safety behavior. *Safety Science* 46 (3), 398-404.

Reason, J., 1995. A systems approach to organizational error. *Ergonomics* 38 (8), 1708-1721.

Reason, J., 1997. *Managing the Risk of Organizational Accidents*. Ashgate Publishing Limited, Aldershot, England.

Satorra, A., Bentler, P.M., 2001. A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika* 66, 507-514.

Siu, O.L., Phillips, D.R., Leung, T.W., 2004. Safety climate and safety performance among construction workers in Hong Kong: The role of psychological strains as mediators. *Accident Analysis and Prevention* 36, 359-366.

Ullman, J.B., 2006. Structural equation modeling: Reviewing the basics and moving forward. *Journal of Personality Assessment* 87 (1), 35-50.

Vroom, V.H., 1964. *Work and Motivation*. John Wiley, New York.

Yiu, C.Y., 2007. Building depreciation and sustainable development. *Journal of Building Appraisal* 3 (2), 97-103.

- Zhou, Q., Fang, D., Mohamed, S., 2011. Safety climate improvement: Case study in a Chinese Construction Company. *Journal of Construction Engineering and Management* 137 (1), 86-95.
- Zohar, D., 1980. Safety climate in industrial organizations: Theoretical and applied implications. *Journal of Applied Psychology* 65 (1), 96-102.
- Zohar, D., 2002. Modifying supervisory practices to improve subunit safety: A leadership-based intervention model. *Journal of Applied Psychology* 87 (1), 156-163.
- Zohar, D., 2003. Safety climate: Conceptual and measurement issues. In: Quick, J.C., Tetrick, L.E. (Eds.), *Handbook of Occupational Health Psychology*, American Psychological Association, Washington, D.C., pp. 123-142.
- Zohar, D., 2010. Thirty years of safety climate research: Reflections and future directions. *Accident Analysis and Prevention* 42 (5), 1517-1522.

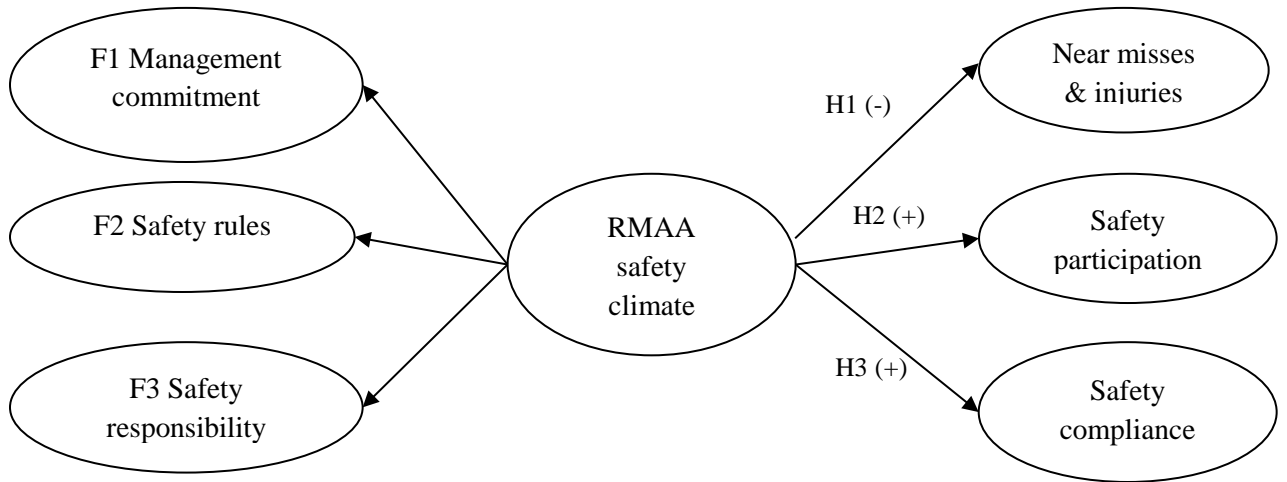


Fig. 1. Research model and hypotheses.

Note. F1 = Management commitment to OHS and employee involvement. F2 = Applicability of safety rules and practices. F3 = Responsibility for health and safety. H1 = Hypothesis 1. H2 = Hypothesis 2. H3 = Hypothesis 3.

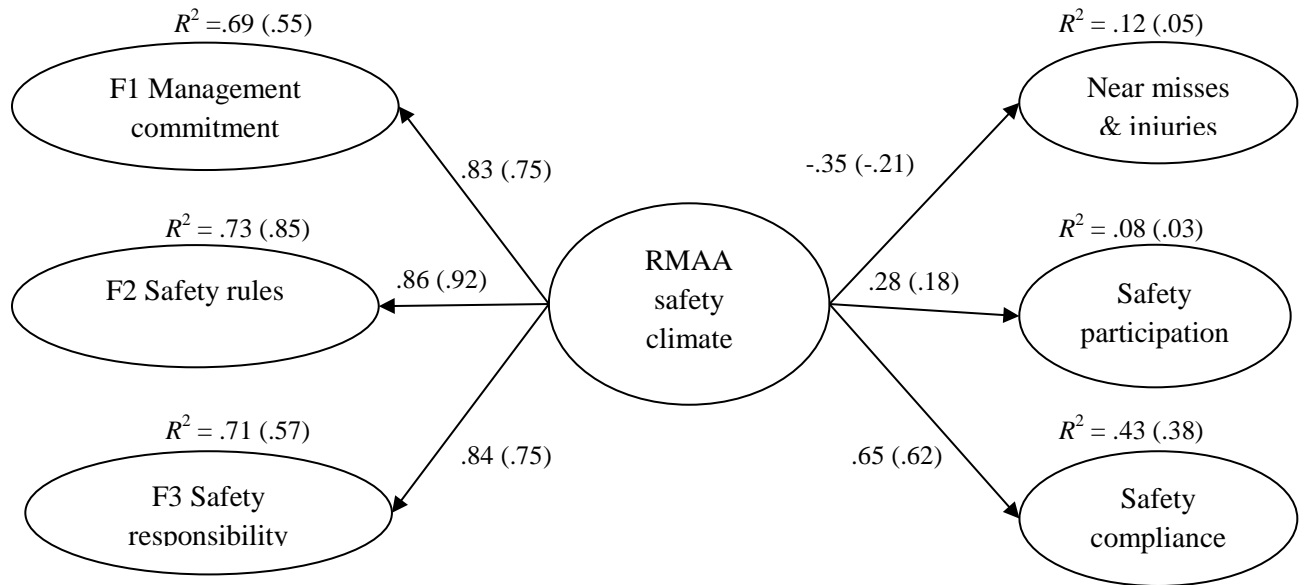


Fig. 2. Empirically tested structural equation model on the calibration sub-sample and (the validation sub-sample).

Note. F1 = Management commitment to OHS and employee involvement. F2 = Applicability of safety rules and practices. F3 = Responsibility for health and safety. Values on the arrows are the standardized (beta) path coefficients. All paths are significant at .01 level. Values in parentheses are from the validation sub-sample. Error terms and disturbances are omitted for clarity of presentation.

Table 1

Mean, standard deviation, and correlation of latent variables.

	Mean	Standard deviation	F1	F2	F3	Near misses & injuries	Safety participation
F1 Management commitment	3.90 (3.89)	0.46 (0.45)					
F2 Safety rules	3.15 (3.19)	0.71 (0.64)	.52** (.46**)				
F3 Safety responsibility	3.55 (3.61)	0.67 (0.65)	.46** (.48**)	.52** (.48**)			
Near misses & injuries	1.31 (1.24)	0.62 (0.54)	-.25** (-.08)	-.21** (-.22**)	-.11 (.03)		
Safety participation	3.35 (3.44)	1.13 (1.08)	.20** (.12)	.17* (.10)	.08 (.03)	-.10 (-.08)	
Safety compliance	4.48 (4.55)	0.50 (0.48)	.48** (.43**)	.44** (.46**)	.26** (.14)	-.20** (-.20**)	.18* (.24**)

Note. Values not in parentheses are from the calibration sub-sample. Values in parentheses are from the validation sub-sample.

** $P < .01$. * $P < .05$.

Table 2

Goodness-of-fit of the Structural Equation Model.

Goodness-of-fit measures	Calibration sub-sample	Validation sub-sample	Tight cross-validation
χ^2	454.06 ($p < .001$)	562.72 ($p < .001$)	1531.98 ($p < .001$)
χ^2/df	1.22	1.52	1.90
RMSEA	.03	.05	.07
90% CI for RMSEA	.02; .04	.04; .06	.06; .07
CFI	.99	.97	.95
NNFI	.99	.97	.95

Appendix A. 22 statements measuring RMAA safety climate.

Factor 1 Management commitment to OHS and employee involvement

The company really cares about the health and safety of the people who work here
There are good communications here between management and workers about health and safety issues

The company encourages suggestions on how to improve health and safety

I am clear about what my responsibilities are for health and safety

I think management here does enough to follow up recommendations from safety inspection and accident investigation reports

All the people who work in my team are fully committed to health and safety

There is good preparedness for emergency here

Accidents which happened here are always reported

Most of the job-specific safety trainings I received are effective

I fully understand the health and safety risks associated

Safety inspection here is helpful to improve the health and safety of workers

Staff are praised for working safely

Factor 2 Applicability of safety rules and work practices

Some jobs here are difficult to do safely

Not all the health and safety rules or procedures are strictly followed here

Some of the workforces pay little attention to health and safety

Some health and safety rules or procedures are difficult to follow

Supervisors sometimes turn a blind eye to people who are not observing the health and safety procedures

Sometimes it is necessary to take risks to get the job done

Factor 3 Responsibility for health and safety

People are just unlucky when they suffer from an accident

Accident investigations are mainly used to identify who should be blamed

Work health and safety is not my concern

Little is done to prevent accidents until someone gets injured

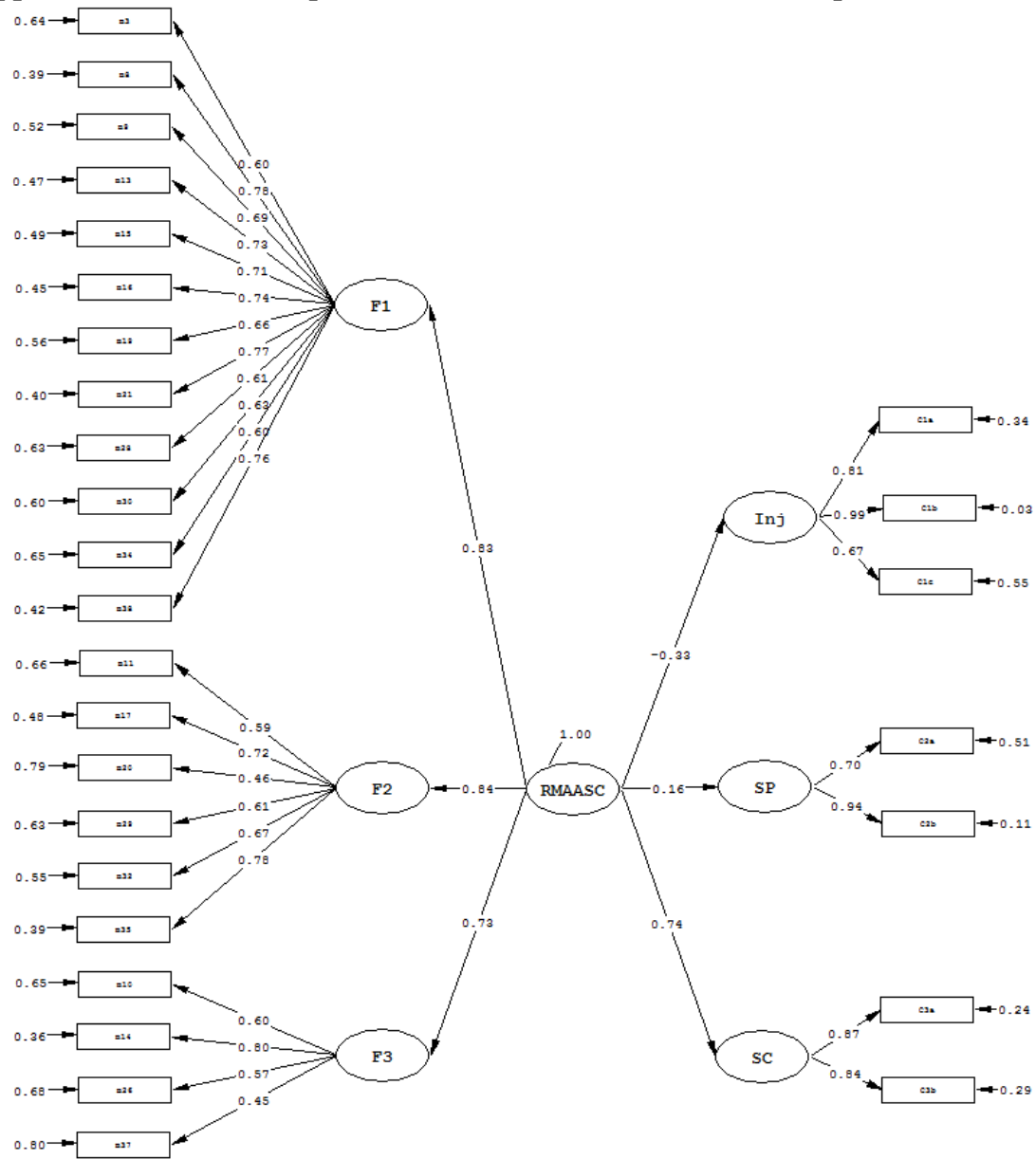
Appendix B. Scales of Safety Participation and Safety Compliance

Please answer this section by circling the most appropriate numbers.

1. Safety Participation (0 = Never; 1 = Yearly; 2 = Monthly; 3 = Weekly; 4 = Daily)					
a) How frequent do you put in extra effort to improve safety of the workplace (e.g. reminding coworkers about safety procedures at work)?	0	1	2	3	4
b) How frequent do you voluntarily carry out tasks or activities that help to improve workplace safety (e.g. attending safety meeting, receiving safety training)?	0	1	2	3	4

[illegible]

Appendix C. Structural equation model of the calibration sub-sample.



Appendix D. Structural equation model of the validation sub-sample.

